Occasional Paper: Scientific Foundations for Countering Terrorism

Summary

The Office of Science supports a broad spectrum of activities that can advance the technologies for countering terrorism. To be effective, we must understand the context in which our science can play a role; we must be aware of critical technology gaps; and we must maintain close interactions with front-line agencies such as the National Nuclear Security Administration (NNSA) and the Department of Defense (DOD). Recent studies have shown that the Office of Science can contribute significantly to a long-range basic research program for countering terrorism by virtue of our ongoing portfolio of programs.

Recent events have raised awareness of our vulnerability to terrorist attacks, and many new homeland security measures have been instituted to respond to these threats. Our Nation's immediate responses, by necessity, have relied on proven technologies that can be deployed to the field now. However, the underlying problem is long term and our strategies must address increasingly sophisticated terrorist activities. Thus, it is prudent that the Federal government initiate a plan that includes long-term, fundamental research to develop new capabilities for the detection, analysis, isolation, and interdiction of the materials that terrorists might use to attack us. Furthermore, we must also prepare to deal with the aftermath of terrorist incidents by being able to detect, isolate, and mitigate the effects of toxic and infectious agents that may be released into our environment.

The Office of Science has exceptionally strong and diverse national laboratory and university programs in areas that can impact the ability to detect, prevent, protect against, and respond to terrorism. For example, chemical and biological sensors, radiation detectors, chemlab on a chip, and genomic analysis could all be important to the *detection* of terrorism. *Prevention* of terrorist acts could be enhanced through improved methods for controlling and tracking radiological materials and the development of new manufacturing methods that minimize the creation of hazardous industrial chemicals. Likewise, *protection* against terrorism could be increased through improved filters and membranes and the development of new protective fabrics. Improvements in our ability to *respond* to a terrorist event could be made by developing methods to immobilize and neutralize hazardous materials, to detect exposure to toxic or infectious agents, or to carry out rapid forensic analyses associated with attribution.

The Office of Science also operates unique facilities that can be applied to research for countering terrorism. These include world-class facilities for materials research, centers for rapid genome sequencing and analysis, and an emerging unique set of centers for

the study of nanoscale science. Many Office of Science researchers at the national laboratories have close interactions with, and partial support from, DOE defense programs. Thus the Office of Science can act as a bridge between basic research programs and classified defense programs, which is extremely important for understanding the technology gaps where scientific research can feed into defense technology development.

Effective response to terrorist threats ultimately will involve new technologies. A wide range of new nanophase materials will be needed as catalysts, sensors, semi-conductor detectors, solid-state lasers, membranes, lightweight structures, and molecular electronic and optical materials.

Fundamental theoretical and experimental tools and models to probe molecular interactions with solid/vapor and solid/liquid interfaces will be critical to development of new selective sensors, transport and fate models, development of improved separations chemistry, and development of new protective barrier and catalytic materials for protective clothing and toxin neutralization. Stand-off detection and integrated systems will require new, compact, solid-state laser sources, semiconductor/biological interfaces, luminescent nanoparticles, and improved data analysis and data mining algorithms.

Sensing and tracking of radiological material will require new capabilities for stand-off detection and scanning of transport vehicles and containers. Ideally, portable, field-deployable detection equipment will be networked to provide real time data on movement. New technologies for security scanning systems will require advanced methods for detecting explosives and biological agents as well as nuclear material.

Dealing with biological threats will require DNA sequencing of microbial pathogens and their genetically close relatives and the analysis of the DNA sequence data to identify biological targets (DNA or proteins) that could be used to detect, characterize, or for forensic analysis of pathogens and to identify target proteins and their mechanisms of action in the virulence process to develop vaccines and therapies.

DNA sequence data contributes directly to DOE/NNSA work to develop DNA signatures for pathogens in conjunction with CDC, FBI and other public health and law enforcement agencies. For example, pathogen survival, propagation and evolution, their invasion and growth in hosts, and their disease mechanisms are all mediated by their genetic instructions and protein molecular machines. This fundamental information is needed to fully understand what makes a potential threat agent a threat, how it can be detected, and how it can be counteracted.

Finally, advanced computational tools will be required for dealing with the massive amounts of data that will accompany widespread sensing and analysis of potential threats. For example, we will require the ability to compare and analyze the DNA sequences of tens to hundreds of microbes at the same time, to predict the biological effects and behavior of a microbe from its DNA sequence, to organize the enormous amount of information being generated on all microbes of interest, to help design and predict effects of drugs and other molecular intervention strategies aimed at defeating biothreat agents.

The Unique Role of the Office of Science in Countering Terrorism

The assets of the Office of Science are unique and can provide the critical scientific

research and development capability that is needed for technology development to counter terrorism. Advanced X-ray light sources, intense neutron sources, and electron microscopes are powerful tools for the analysis of materials. Genomic sequencing centers and high performance computer resources are critical for the rapid analysis and modeling of biological threats. We are world leaders in high energy and nuclear physics with the ability to greatly advance the detection and characterization of nuclear materials. Our system of National Laboratories provides a unique environment for scientific investigation coupled to the world's most advanced facilities.

The Office of Science programs have a long history of close interaction with defense-related components of the DOE and the DOD. We also lead the Nation in the support of university research in the physical sciences. More than any other agency we are positioned to bridge the gap between unclassified basic research and classified "behind the fence" research associated with homeland security and countering terrorism.

Much of the research associated with countering terrorism will have dual use. For example, new sensors and detectors with "single molecule" detection capability and high specificity will be very important in chemistry and materials research. New capabilities in genomic analysis and systems biology associated with biological pathogens will also impact microbial and plant biology research for energy and the environment. New capabilities for handling and analyzing massive data sets will impact our research in high-energy physics, atmospheric modeling, and materials science.

As the Nation prepares for the next phases of the War on Terrorism, a strong research base is going to be required to fuel the development of new technologies for front-line defenders, first responders, and critical decision makers.

The Office of Science, with its unique combination of laboratory and university research coupled to unique, world-class facilities for scientific discovery, can assume a major role in the scientific research for countering terrorism.

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